Annexure – I

Design, Detailed Engineering, Fabrication, Assembly, Inspection, Load Testing, Supply, Installation & Commissioning of PS4 propellant tank automated cleaning system as per the following requirements and terms & conditions.

INTRODUCTION

Three versions of propellant tanks (L2.5, L2.0 & L1.6) are used in PS4 flight stage for storing propellants in two compartments(MMH & MON3). The internal surfaces of the propellant tank has to be cleaned using cleaning solvent- Iso Propyl Alcohol (IPA) to the acceptance level of contamination. The propellant tank has to be cleaned using Programmable three axis automated actuation system (3 axis : 360 deg. clockwise and anticlockwise rotation along longitudinal X-axis, 180 deg. forward & reverse swing along lateral Y- axis and 90 deg. tilting horizontal to vertical & vice versa along Z-axis) and IPA servicing system.

PS4 propellant tank automated cleaning system shall consists of two sub-systems

I. Programmable three axis automated actuation system
II. IPA servicing system

I. Programmable three axis automated actuation system

1.1 Functions

- To mount three versions of the propellant tanks (L2.5, L2.0 & L1.6) firmly.
- The propellant tank has to be mechanised to get tumbling action of cleaning solvent(IPA) inside the propellant tank as shown in Figure-1 by incorporating the following motions as given in Figure-2.
  - 360 deg. clockwise and anticlockwise rotation along longitudinal X-axis
  - 180 deg. forward & reverse swing along lateral Y- axis
  - 90 deg. horizontal to vertical & vice versa tilting along Z-axis

Proper mechanism shall be incorporated with three axis (X, Y & Z) actuation simultaneously with variable rotation/speeds and also actuation of each axis (X/Y/Z) discretely with variable rotation/speeds.

1.2 Conceptual Design of system

PS4 propellant tanks are fabricated using Titanium Alloy (Ti6Al4V). It is cylindrical in shape with ellipsoidal end domes. It consists of two compartments for fuel (MMH) and oxidizer (MON3). The minimum thickness of propellant tank is 1.5 mm. Three versions of propellant tanks (L2.5, L2.0 & L1.6) are used in PS4 flight stage. The dimensions, volume and weight of the each version are mentioned in section 1.3.2. The different version of propellant tank to be cleaned are given in Figure-3. The propellant tank has to be cleaned using cleaning solvent-IPA to the acceptance level of contamination using programmable three axis automated actuation system and IPA servicing system.

1.3. Scope of work

1. Carrying out Detail Design of the system.
2. Detailed Engineering.
3. Design review by IPRC.
4. Preparation of fabrication drawing.
5. Fabrication of the system.
6. Inspection and load testing.
7. Supply, installations and commissioning.

1.3.1 Design

The Conceptual drawing for Programmable three axis automated actuation system is given in the Figure-1. This figure is provided for reference only. Party can configure his own concept to hold the propellant tank positively and achieve all the required motions. However, it is the responsibility of the party to design and prepare the detailed drawings for fabrication of the automated cleaning system.

Since the thickness of the propellant tanks is in the order of 1.5mm, proper care shall be taken while design the system and ensure that there is no undue force acting on the hardware during cleaning.

1.3.2 Detailed engineering

Based on the approved design evolved during design review at IPRC, the contractor shall carry out detailed engineering, which shall meet the following:

Requirements

i) Details of Propellant Tanks to be cleaned

Sl. No	Description	Version		
		L2.5	**L2.0**	**1.6**
1	Material >Propellant tank	Ti6Al4V	Ti6Al4V	Ti6Al4V
	>Internal baffle assembly	Al. alloy	Al. alloy	Al. alloy
2	Length, mm	2012	1680.5	1431.5
3	Inner Dia, mm	1335	1335	1335
4	Fore end & Aft end Flanges O.D	1385	1385	1385
5	Size, No. of holes and PCD on Fore end & Aft end flanges	Ø8.4 holes – 36 Nos. equispaced on PCD 1370	Ø8.4 holes – 36 Nos. equispaced on PCD 1370	Ø8.4 holes – 36 Nos. equispaced on PCD 1370
6	**Volume of tank (litres)**			
	MMH compartment	1287	1030	830
	MON3 compartment	1090	884	734
7	**Mass of the tank**, kg	141	128	121

ii) Fixture

Propellant tank should be firmly connected to the rotating fixture using bolts & nuts fastened at fore end and aft end flange PCD holes.

iii) Actuation system

- Axis of actuation : 3 axis
  1) 360 deg. clockwise and anticlockwise rotation along longitudinal X-axis
  2) 180 deg. forward & reverse swing along lateral Y- axis
  3) 90 deg. horizontal to vertical & vice versa tilting along Z-axis
- Speed of rotation : 2 to 20 rpm. (Variable)
- Swing speed : 5 to 20 Sec. per cycle (Variable)
- Tilt speed : 5 to 20 Sec. per cycle (Variable)
- Drive for rotation : AC Motor with VFD gear drive
- All motors, connectors and control panel should be flame proof (Group IIA)
- Mechanical stoppers should be provided for swing along lateral axis-Y and tilt along Z- axis in addition to the electrical limit switches.
- Mechanism should be such that no manual intervention is permitted during operation.
- Proper mechanism should be incorporated with three axis (X, Y & Z) actuation simultaneously and shall be synchronised with variable rotation/speeds and also actuation of each axis (X / Y / Z) discretely at any position with variable rotation/speeds.

iv) Control unit

- Programmable logic controlled (PLC) system used for speed setting of rotation, swing & tilt and idle time etc.
- Motors & control panels are of class Group II A.
- All control buttons like emergency stop, speed setting of rotation, swing & tilt, idle time setting etc. should be incorporated
- Control switches shall be provided for simultaneous motions (X, Y & Z) and individual motions (X / Y / Z).
- Control unit should be placed 10 metres away from the system.
- Siemens or Fanuc or L&T make controllers for Programmable Logic Controller (PLC), Variable Feed Drive (VFD) and servo motor .
- Emergency stop should be provided for all actuations.

v) Remote Control

- Remote control should be placed 10 mtrs. away from the system.
- Flame proof (Group IIA) fittings.
- Siemens or Fanuc or L&T make controllers.
- All control switches should be incorporated.

vi) Fore end & aft end support unit

These units should hold the propellant tank securely without transferring any loads to the propellant tank.

- Material : IS 2062
- 36 nos. of holes (dia. :9 mm) are to be provided on each fore end & aft end units (ref. Figure-3).
- Total nos. of fasteners to hold propellant tank : 36 nos. each on fore end & aft end units (ref. Figure-3).
- Dowel pin hole -2nos. (dia. : 6 mm) should be provided on fore end & aft end support units as per the Figure-3.
- The fore end / aft end support units can be moved forward and reverse manually and can be held in any position to assemble three versions of propellant tank.
- It shall have guide ways for achieving the centre at any length to hold three versions of propellant tank.

vii) Dummy load for load testing

- Material : IS 2062

- Dummy load should have the interface on both ends as in Fore end & aft end support unit.
- Dummy load should be in cylindrical shape and having hook points with CG balanced.

- 36 nos. of holes (dia. 9 mm) are to be provided on both ends of dummy load. (ref. Figure-3 & 4).
- Dowel pin hole -2nos. (dia. 6 mm) should be provided on both ends of dummy load as per the Figure-3 & 4.
- Realisation of dummy load shall be under the scope of supplier.
- Dummy load shall be supplied along with the system.
- Actual FESU & AESU shall be used to hold dummy mass (m3) weighing 500 kg.

viii) Bought out items

Fasteners	:	Unbrako / TVS, property class12.9
Bearings	:	FAG. /SKF/NTN
Geared-motor	:	Rotomotive /Bonfiglioli
Starter Components	:	Siemens / L&T/Fanuc.
VFD	:	Siemens / L&T/Fanuc/Telemecanique (Schneider)
Servo motor & drive	:	Siemens / L&T/Fanuc/Telemecanique (Schneider)

NOTE

- All the Electrical or Electronic items/fittings should be flame Proof.
- The above specifications are for reference only. The specifications may be changed based upon the review of detailed design.
- A fail-safe clamping scheme using 36 nos. of fasteners each at fore end and aft end flange of propellant tank with the system ring.
- The rotating system rings should not be damage the tank flanges at clamping locations.
- The system should have hook points for handling.
- Mechanism shall be such that filling and draining of the cleaning fluids is possible through both the tank openings with suitable closure when tank is mounted on the Automated rotating system. It is planned to use

approximately 100 liters of IPA as cleaning fluid at a time in both compartments (50 litres each).

- Mechanism should be that propellant tank can be rotated/swung/tilted in three axes(ref. Figure-1 & 2) i.e. rotation along longitudinal axis-X, swing along lateral axis-Y and tilt (0-90 deg.) along Z-axis (horizontal to vertical and vice versa) simultaneously and shall be synchronized such that cleaning fluid inside the tank shall wet the entire internal surface.
- Also the mechanism should be incorporated that propellant tank rotation, tilt & swing (X/ Y/ Z) discretely at any position.
- A minimum ground clearance of 500 mm should be available when tank is held in vertical condition to facilitate draining of cleaning fluid from tanks easily.
- Tanks shall be loaded on to the automated rotating system by using crane.
- Clamping mechanism should have the flexibility to accommodate three versions of propellant tanks.
- The materials of construction shall be IS 2062
- Mechanism shall be such that no manual intervention is required once the tank is loaded in the fixture, filled with cleaning fluid and motor is switched ON.
- Mechanism shall be designed such that MMH/MON3 tank cleaning closures with valve and QC/DC should not be damaged during the course of actuation.
- Mechanism shall have all safety features essential for continuous day-to-day operation.
- CG of the mechanism, in tank loaded and wetted condition shall be as low as possible so that mechanism is stable.

Method of mounting of tank

The propellant tank has to be fixed with the system by M8 fasteners using suitable fore & aft end support unit/ring on fore end flange (Ø8.4 holes – 36 Nos. equispaced on PCD 1370mm) and aft end flange (Ø8.4 holes – 36 Nos. equispaced on PCD 1370mm) as per Figure-3.

1.3.3 Design review by IPRC

As stated in section 1.0, 1.1 and 1.3.1, the conceptual drawing (refer fig.-1 & 2) is provided. The department will organize a design review meeting at IPRC, Mahendragiri after completion of detailed design of the system by the party in which the contractor's representative(s) shall present the design details.

The objective of the design review is to arrive at a consensus between the department and the contactor on the design of programmable three axis automated rotating system and IPA servicing system to freeze the input data for the detailed engineering to be done by the contractor.

In case the contractor prefers to employ the alternative method, the department may agree, provided that the basic concept should not be changed. In such case where the contractor employs alternative method, it shall be their responsibility to present the design detail to the department design review. The design review shall primarily address the following issues:

- Design of all rotating member to comply with specified functional requirements.
- Adequacy of the in-built safety features.
- Adequacy of safety margin of components (Minimum 2 for impact load).
- Safety of hardware during handling and operation.

1.3.4 Preparation of fabrication drawings

After design review, the department will review the detailed engineering done by the contractor. After review of detailed engineering, the party should prepare the fabrication drawings and obtain the approval from department prior to start of fabrication.

1.3.5 Fabrication

a) Fabrication should be carried out as per the dimensions and tolerances in the fabrication drawings.
b) Unless other specified general tolerance as per IS have to be followed.
c) Workmanship shall be very high quality. Skilled and qualified welders are to be employed.
d) Good engineering practices shall be followed.
e) All the components shall be machined to the surface finish and geometry as indicated in the detailed fabrication drawing.
f) Minor modification required by IPRC, during fabrication shall be carried out without any extra cost.
g) All weld joints should confirm to IS codes and should be DP tested.
h) Threading on the mating parts to be matched without ply.
i) The machining surfaces at the interface should match exactly when assembled. All the assembly shall be provided with fasteners and with minimum property class 10.9.
j) No deviation from the drawing specification is permitted without IPRC approval.

1.3.6 Inspection & load testing

The inspection of the system during fabrication at various stages will be carried out by department Engineer's and a final inspection will be done at IPRC after commissioning the system. Material test certificates for mechanical and chemical properties, dimensional inspection reports, DP reports as well as manufacturer's test certificates for bought out items should be submitted at the time of inspection.

The Automated rotating system has to be load tested for specimen weight of 500 Kg for dynamic loading condition at party's site as per configuration shown in section 1.3.2 and as per the Figure-4. Necessary load set up and conduct of load

test in the presence of IPRC's representative shall be arranged by the party. The load test configuration has to be worked out in advance in consultation with IPRC.

1.3.7 Supply, installation and commissioning

The system is to be erected by the contractor at the department's site. The works done by the contractor during erection shall be inspected by department's representatives(s). The erection shall also include a trial cleaning & testing, minor civil works (for grouting of equipments, supports, cable trench, etc). After successful erection of the system at department's site, the system shall be commissioned by the party for its functional requirement.

Party shall provide detailed product catalogues for the standard items used in the mechanism including the part numbers and supplier name along with the guarantee certificates.

II IPA servicing system

2.0 Introduction

- The cleaning solvent (IPA) has to be filled and drained in the propellant tank assembled with programmable three axis automated rotating system.

2.1 Conceptual Design of system

The MMH tank cleaning closure with ball valve and female QC/DC (ID:16 mm) shall be assembled with propellant tank fore end opening (MMH tank). Another ball valve with QC/DC (female) shall be assembled with the MMH outlet port (M30x1.5) using conversion adaptor for filling & draining of IPA.

The MON-3 tank cleaning closure with ball valve and female QC/DC (ID: 16mm) with propellant tank aft end opening. This system consists of storage tank (capacity:250 litres) for IPA storage, chemical transfer pump (flame proof type), filters, manual valve (ball valve), SS tubes, SS braided PTFE flexible hoses and QC/DC as shown in figure-5.

The filter unit should be removable type which need to be cleaned frequently. The outlet port of IPA fill & drain system and respective ball valves assembled to the tank shall be connected through a SS braided PTFE flexible hose with QC/DC (male).

2.2 Scope of work

1. Carrying out Detail Design of the system.
2. Detailed Engineering.
3. Inspection
4. Testing
5. Supply, installation and commissioning

2.2.1 Design

The Conceptual drawing for IPA servicing system is given in the Figure-5. This figure is provided for reference only. However, it is the responsibility of the party to prepare the detailed schematic and fabrication drawing of the system. There can be variations between the conceptual drawing supplied by us and new schematic drawing of IPA servicing system prepared by the party. The concept of servicing system and specified requirement should not be changed.

2.2.2 Detailed engineering

Based on the approved design evolved during design review, the contractor shall carry out detailed engineering, which shall comprise the following:

Requirements

i) Servicing pump

- Type : Mono-Block centrifugal magnetic coupled chemical pump with motor mechanically coupled sealless pump.
- Material of construction : PP
- Capacity : 15 m3/hr.
- Head : 23 m
- Liquid temperature : up to 100 degree centigrade
- Liquid specific gravity : up to 1.8
- System pressure : up to 3 bar at 20 degree centigrade
- End connection : BSP threaded
- Fluid : Iso Propyl Alcohol

Electrical : Motor suitable for operation in flammable area confirming to IS 2148 Group IIA.

- Phase : 3
- Voltage : 440 V, 50 Hz
- Power : 3.7 kW
- Speed : 2900 rpm
- Motor & electrical Fittings : Flame proof as per IS 2148 Group II A
- Temperature class : T4 & IP 65

ii) Filters

- Material of construction : SS316/SS304
- Filter element : SS Pleated mesh only
- Filter rating : 40 microns (absolute)
- Pressure range : 10 bar
- Quantity : 2 nos.

iii) Manual ball Valves(MV)

- Make : Butech/ORSEAL/Swagelok/Equivalent
- Material of construction : SS316
- Size : 1 inch
- Working pressure : 10 bar
- Medium : IPA
- Quantity : 7 nos.

iv) Tubings

- Material : SS 316
- Make : Sandvik
- Tube size : ∅18x1
- Quantity : as required

v) Flexible hoses

- Material : SS braided PTFE
- Size : Dia. 16 mm(M26X1.5) X 13 metre (L)
- Pressure rating : 10bar
- Quantity : 2 nos.

vi) QC/DC

- Material : SS 316
- Size : 1 inch
- Pressure rating : 10 bar
- Quantity : 6 sets

vii) Storage tank

- Material : SS304L/SS 316
- Capacity : 250 liters

viii) Adaptors

Adaptors should be used between fluid components viz., storage tank, manual valve, filters, servicing pump, QC/DC etc., and tubes / flexible hoses for easy removal/assembly of fluid components for servicing/replacement.

Adaptor size should match with the fluid component's end size and tubes / flexible hoses having nut (M26X1.5) & nipple (Ø 16).

Method of operation

The cleaning solvent (IPA) has to be filled and drained in the propellant tank assembled with Automated rotating system.

The IPA stored in the SS tank has to be filled to the propellant tank using a servicing pump through set of valves, tubes, filters, hoses and QC/DC. The filled IPA is used to clean the propellant tank internal surfaces by the tumbling action of the propellant tank using the Programmable three axis automated actuation system.

Then the IPA has to be drained from the propellant tank to the SS tank by gravity through set of valves, tubes, hoses and QC/DC. The same procedure has to be repeated till the propellant tank cleaned to the required cleanliness level.

Other Conditions

- All weld joints have to be DP tested
- Threading on the mating parts to be matched without ply.
- The storage tank & tubes should be pickled & passivated.
- All the items are to be assembled in system by optimal layout and size of the system should be compact. Layout plan and overall system envelope size to be specified in the offer.
- Suitable support structure shall be provided for mounting of all fluid components including tank. A minimum height of 350mm to be maintained from SS tank top surface to the ground.

- The support structure material will be SS sheet and SS angle with dull finish polish.
- System should have the provision for easy removal of components for repair/ testing.
- All the fluid circuit and components are to be designed for operating pressure of 10 bar.
- The thickness reduction in tubes should not be more than 10% and bends to be wrinkle free.
- Usage of Teflon tape and thread sealant should be avoided in the fluid circuit to prevent the generation of contamination. BSPP type connection with gasket is acceptable.
- All the Electrical or Electronic items must be Flame Proof(Group II A)
- Nominal filters to be selected with SS pleated mesh type only.
- Mimic diagram of the system shall be affixed for reference.
- Good quality PTFE flexible hoses are to be used.
- Suitable hook provision to be made on system at four locations for handling purpose.

2.2.3 Inspection

The inspection of the system during fabrication at various stages will be carried out by department Engineer's and a final inspection will be done at IPRC after commissioning the system. Material test certificates for mechanical and chemical properties, surface treatment, DP reports as well as manufacturer's test certificates for bought out items should be submitted at the time of inspection.

2.2.4 Testing

- Individual fluid circuit to be tested hydraulically to a pressure of 15 bar.
- Leak test to be conducted for SS tank.

2.2.5 Supply, installation and commissioning

The system is to be installed by the contractor at the department's site. The works done by the contractor during installation shall be inspected by department's representatives(s). The installation shall also include a trial cleaning & testing. After successful installation of the system at department's site, the system shall be commissioned by the party for its functional requirement.

Party shall provide detailed product catalogues for the standard items used in the mechanism including the part numbers and supplier name along with the guarantee certificates.